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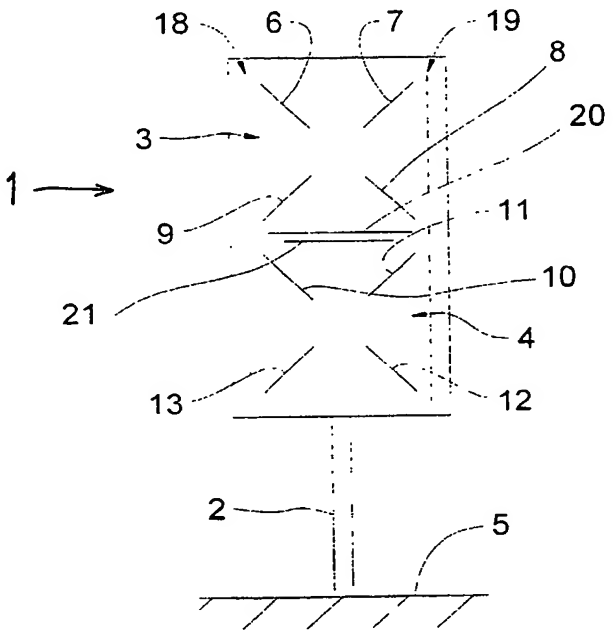
(54) Title: A DUAL POLARISED ANTENNA



(57) Abstract: A dual polarised antenna comprising a reflector (101); one or more radiating element (102-104); and a plurality of directors (107-116) extending from the reflector dimensioned and positioned to emphasise one polarisation of the beam of the antenna at angles away from the main beam direction. The directors are in the form of fingers which act as resonant monopoles so as to produce beam equalising currents.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A DUAL POLARISED ANTENNA

The present invention relates to a dual polarised antenna. More particularly, but not exclusively, the present invention relates to a dual polarised antenna suitable for use in cellular communication applications at frequencies between 400 to 3000 MHz.

For dual polarised antennas used in cellular communication applications it has been found desirable to skew the radiating elements at + 45° and - 45° to vertical. Such antennas typically have beam widths of 60 to 120°. It would be desirable for the horizontally polarised component to be the same as the vertically polarised component at all beam angles. However, for a standard dipole the vertical component remains substantially constant, whereas the horizontal component is increasingly attenuated, at angles away from the main beam direction.

NZ333517 discloses an antenna in which slots in a wall are utilised to provide equalisation of the polarisations. The position of the slots cannot be changed independently of the position of the wall. Therefore although polarisation equalisation may be achieved, this approach limits design freedom and may result in other antenna characteristics being compromised.

It is an object of the present invention to provide a dual polarised antenna having substantially balanced vertical and horizontal components over a wide range of angles from the bore sight, which allows greater design freedom and improved performance, or which at least provides the public with a useful choice.

According to a first aspect of the invention there is provided a dual polarised antenna comprising,

a reflector;

one or more radiating element; and

a plurality of directors extending from the reflector dimensioned

and positioned to emphasise one polarisation of the beam of the antenna at angles away from the main beam direction.

The invention provides an alternative arrangement to the slots of NZ333517. The position of the directors can be altered independently of the other antenna components.

Typically the reflector comprises a conductive sheet (which acts as a ground plane) which is electrically coupled to the directors.

Preferably a plurality of the directors are positioned on a first side of the radiating element(s) and a plurality of the directors are positioned on a second side of the radiating element(s). Typically the directors positioned on the first side of the radiating element(s) are substantially aligned with the plurality of directors positioned on the second side of the radiating element(s). In a preferred embodiment, at least some of the directors are aligned with a respective radiating element (typically aligned horizontally).

Typically the directors positioned on the first side of the radiating element(s) are arranged in a first row, the directors positioned on the second side of the radiating element(s) are arranged in a second row, and the first and second rows are substantially parallel with each other.

The directors may be formed in a variety of shapes, depending on the design of the radiating element(s), and the desired beam width. However preferably the directors are elongate fingers. The fingers are typically rectangular, most preferably in strip form. This provides for ease of manufacture.

Typically the directors extend substantially at right angles from a substantially planar reflector.

The radiating element(s) may be patch elements, but preferably the, or each, radiating element comprises a pair of dipoles, each dipole having a pair of arms. Typically the arms are oriented at + 45° or - 45° with respect to vertical, and may be inclined towards the reflector.

In one embodiment, the pair of dipoles are in a conventional "crossed-dipole" arrangement. In another embodiment, the or each radiating element comprises first, second, third and fourth dipoles arranged around a common central axis, each of the dipoles comprising a pair of elongate dipole arms, wherein the arms of the first dipole and the arms of the third dipole extend in a substantially common first plane on opposite sides of the central axis, the arms of the second dipole and the arms of the fourth dipole extend in a substantially common second plane on opposite sides of the central axis, and the first and second planes intersect at the central axis.

At a minimum, only a single radiating element may be provided. However, typically the antenna comprises a plurality of radiating elements, which are preferably arranged in a one dimensional array.

In one embodiment the directors are free standing conductive members connected at one end to the reflector. In another embodiment the directors are each disposed on a face of a dielectric substrate.

Preferably the antenna is suitable for use in a cellular communication system in which the antenna communicates with a mobile communication device.

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a front view of a cellular communication system antenna;

Figure 2 is a schematic circuit diagram showing the beam forming network connected to the dipoles;

Figure 3 is a perspective view from below the antenna showing the antenna elements in more detail;

Figure 3a is a cross section through the PCB;

Figure 4 is a view of a first dipole pair on a board;

Figure 5 is a view of the other side of the board;

Figure 6 is a view of a second dipole pair on a board;

Figure 7 is a view of the other side of the board of Figure 6;

Figure 8 is a perspective view from the right side of the antenna showing the antenna elements in more detail;

Figure 9 is a view of an alternative feed network;

Figure 10 is a perspective view of an alternative dual polarised antenna; and

Figure 11 is a perspective view of the antenna figure 10 from a different angle.

Referring to Figure 1 (which is schematic only), an antenna 1 is mounted on a mounting structure 2. The antenna 1 has a pair of antenna elements 3,4 which are oriented substantially vertically with respect to the ground 5. The element 3 comprises four dipoles 6-9 and the element 4 comprises four dipoles 10-13.

Referring to Figure 2, the dipoles 6,8,10,12 oriented at –45 degrees are connected to a first beam forming network with a single input/output line 14, and the dipoles 7,9,11,13 oriented at +45 degrees are connected to a second beam forming network with a single input/output line 15. Variable phase shifters 16,17 are provided so as to generate downtilt in the transmit/receive beams.

Parallel lines 18,19 of beam forming fingers are arranged on each side of the elements 3,4, and isolation elements 20,21 are arranged between the elements 3,4.

Each isolation element 20,21 may be in the form of a conductive rod, such as the rod described in Figures 5 and 6 of US-A-5,952,983, although other forms of isolation element may be used. The elements 20,21 are of different lengths. The isolation elements generate currents which reduce undesirable coupling between the elements 3,4.

The antenna 1 is shown in more detail in Figures 3-8. The isolation elements 20,21 are omitted from Figures 3-8 for clarity.

The elements 3,4 are mounted on a printed circuit board (PCB) 22 shown in cross section in Figure 3a. The PCB 22 comprises a dielectric board 23 coated with a copper ground plane layer 24 on the same side of the board 23 as the elements 3,4. The input/output lines 14,15 (Figure 2) are formed by etching a copper layer 25 on the rear side of the board 23.

The elements 3,4 are identical and so only the lower element 4 will be described in detail with reference to Figures 4-7.

The dipoles 10,12 form part of a contiguous copper layer 36 deposited by electroplating onto a front face 31 of a dielectric board 30 and shaped by etching. The front and rear faces 31,32 of the dielectric

board are shown in Figures 4 and 5. Each dipole is formed by a pair of collinear strip-like arms 32,33 and 34,35.

A feed network is provided in the form of a contiguous copper layer 37 deposited by electroplating onto the rear face 32 of the dielectric board 30 and shaped by etching.

Prior to electroplating, a pair of holes 38,39 are formed in the board 30. The walls of the holes 38,39 are plated with copper during the deposition process. This provides an electrical connection between the feed element 40 and the arm 35, and between the feed element 41 and the arm 33, without requiring any soldering.

The layer 36 is formed with a cutout 54 to prevent a short-circuit between layer 36 and feed network on board 50, shown in Figure 7.

The board 30 is formed with a slot 42 to receive the other board 50 shown in Figures 6 and 7. The dipoles 13,11 are formed on the board 50 in a similar manner to the dipoles 10,12 on board 50, and therefore only the differences will be described below.

The copper layer 51 is formed with a cutout 52 to prevent a short-circuit between layer 51 and feed network layer 37 on board 30 (Figure 5).

The board 50 is formed with a slot 53 to receive the other board 30.

For illustration, the branching points of the feed network are indicated at 60,61 in Figures 2, 5 and 7.

The layers 36,51 are electrically connected to the ground plane 24 by solder 62,63,64 shown in Figure 3.

The layers 37,55 are connected to the feed network on the opposite face of the board 22 by lines 80,81 which pass through holes (not shown) in the board 22.

Referring to Figure 8, the line 18 of fingers is shown in detail. The fingers are in the form of rectangular copper strips 70,71 etc formed on the outer face 72 of a dielectric board 73 and electrically connected to the ground plane 24.

The fingers 70,71 etc. act as quarter wavelength resonant monopoles producing currents which emphasise the horizontal beam component in order to make it more equal to the vertical beam component.

The length of the fingers is selected to be approximately equal to one quarter wavelength in the wavelength range of interest. The spacing between the fingers is chosen to avoid propagation of travelling waves along the row of fingers. A spacing less than half a wavelength has been chosen in the embodiment shown.

Referring to Figure 9, in an alternative arrangement the plated-through holes 38, 39 may be omitted. In this case the feed elements 40, 41 are formed with arms 90, 91, giving a balun structure in which the feed elements couple capacitively with the dipole arms.

In the alternative embodiment of Figure 10, the antenna includes a plurality of radiating elements 102, 103 and 104 arranged in an array above reflector 101. The number of radiating elements will vary depending upon the requirements of each particular application. The radiating elements may be dipoles or patches.

The radiating elements in this case are dipole pairs 105 and 106 that are orthogonally disposed and are independently fed. Dipoles 105 and 106 are oriented at +45° and -45° to vertical (vertical being the axis of the array along which the radiating elements are aligned). The arms of dipoles 105 and 106 are seen to be inclined downwardly towards reflector 101 to increase beam width.

Directors 107 and 108 act as polarisation sensitive elements which enhance the horizontally polarised components at angles away from the main beam direction of the antenna. This results in the horizontally polarised components being enhanced at beam directions where they would otherwise be weak whilst the vertically polarised components remain substantially unaffected. This results in the horizontally polarised and vertically polarised components being of substantially equal magnitude at all operational beam directions so as to maintain a 45° slant.

In contrast to the directors in the embodiment of Figures 1-9, the directors 107 and 108 are free standing elements connected at one end to the reflector 107.

The directors 107 and 108 are spaced apart from radiating element 102 along the horizontal axis. The length and spacing between the directors are selected using similar considerations to the considerations discussed above with reference to the embodiment of Figures 1-9. Reflections from the directors and radiating element can mutually cancel.

The directors 109 to 112 operate in a similar manner for radiating elements 103 and 104. Further directors 113 to 116 may be provided. As well as providing polarisation equalisation they may provide improved antenna matching. Isolation elements (not shown) may be provided between radiating elements to provide improved

matching.

It will be appreciated that the height and width and position of directors 107 to 112 may be adjusted to achieve a desired beam pattern for a particular antenna.

The present invention thus provides a dual polarised antenna which maintains a substantially constant 45° slant irrespective of antenna beam direction over the operational beam width of the antenna.

The use of directors allows greater design freedom in allowing the directors to be moved independently of one another to achieve a desired beam pattern. Use of beam equalising directors can additionally provide improved antenna matching with the directors serving as external matching elements for the radiating element. This is not possible with the slot type construction of the prior art. The antenna of the invention can also enable reflections from the directors to mutually cancel reflections from the radiating element to a greater extent than can be achieved with the slot type construction.

Where in the foregoing description reference has been made to integers or components having known equivalents then such equivalents are herein incorporated as if individually set forth.

Although this invention has been described by way of example it is to be appreciated that improvements and/or modifications may be made thereto without departing from the scope or spirit of the present invention.

CLAIMS

1. A dual polarised antenna comprising a reflector; one or more radiating element; and a plurality of directors extending from the reflector dimensioned and positioned to emphasise one polarisation of the beam of the antenna at angles away from the main beam direction.

2. The antenna of claim 1 wherein a plurality of the directors are positioned on a first side of the radiating element(s) and a plurality of the directors are positioned on a second side of the radiating element(s).

3. The antenna of claim 2 wherein the directors positioned on the first side of the radiating element(s) are substantially aligned with the plurality of directors positioned on the second side of the radiating element(s).

4. The antenna of claim 2 or 3 wherein the directors positioned on the first side of the radiating element(s) are arranged in a first row, the directors positioned on the second side of the radiating element(s) are arranged in a second row, and the first and second rows are substantially parallel with each other.

5. The antenna of any of the preceding claims wherein the directors are elongate fingers.

6. The antenna of claim 5 wherein the fingers are strips.

7. The antenna of claim 5 or 6 wherein the fingers are substantially rectangular.

8. The antenna of any of the preceding claims wherein the reflector is substantially planar and the directors extend substantially at right angles from the plane of the reflector.

9. The antenna of any of the preceding claims wherein the, or each, radiating element comprises a pair of dipoles, each dipole having a pair of arms.

10. The antenna of claim 9 wherein the arms are oriented at + 45° or - 45° with respect to vertical.

11. The antenna of claim 9 or10 wherein the arms are inclined towards the reflector.

12. The antenna of any of the preceding claims comprising a plurality of radiating elements.

13. The antenna of claim 12 wherein the elements are arranged in a one dimensional array.

14. The antenna of any of the preceding claims wherein the directors are free standing conductive members connected at one end to the reflector.

15. The antenna of any of claims 1 to 13 wherein the directors are each disposed on a face of a dielectric substrate.

16. The antenna of any of the preceding claims wherein the or each radiating element comprises first, second, third and fourth dipoles arranged around a common central axis, each of the dipoles comprising a pair of elongate dipole arms, wherein the arms of the first dipole and the arms of the third dipole extend in a substantially common first plane on opposite sides of the central axis, the arms of the second dipole and the arms of the fourth dipole extend in a

substantially common second plane on opposite sides of the central axis, and the first and second planes intersect at the central axis.

17. The antenna of any of the preceding claims suitable for use in a cellular communication system in which the antenna communicates with a mobile communication device.

18. The antenna of any of the preceding claims wherein the directors are positioned and dimensioned to act as resonant monopoles.

19. A cellular communication system including the antenna of any of the preceding claims.

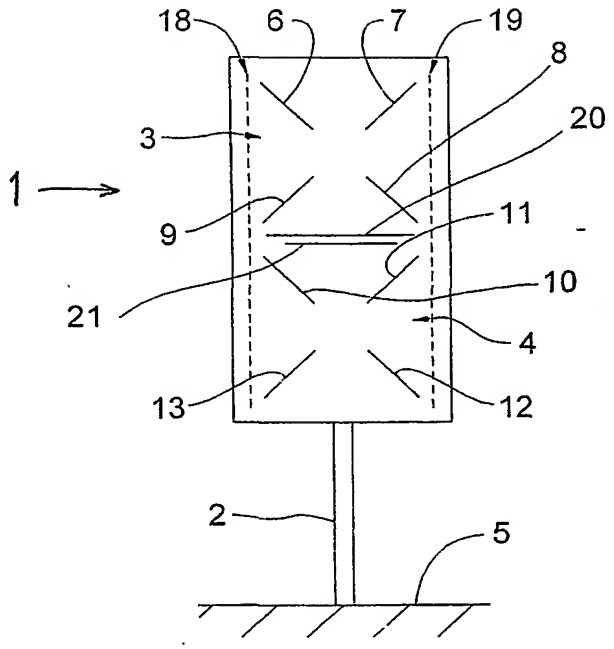


Fig. 1

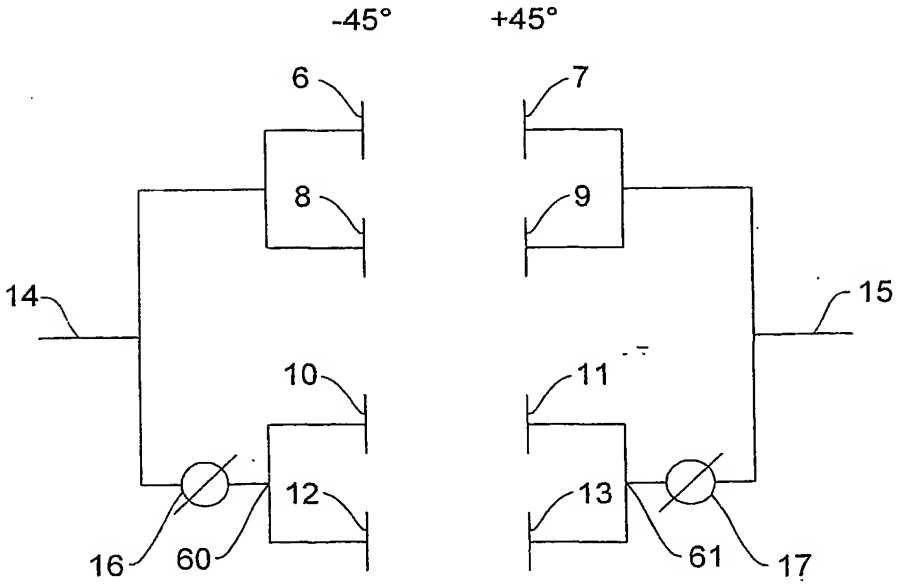


Fig. 2

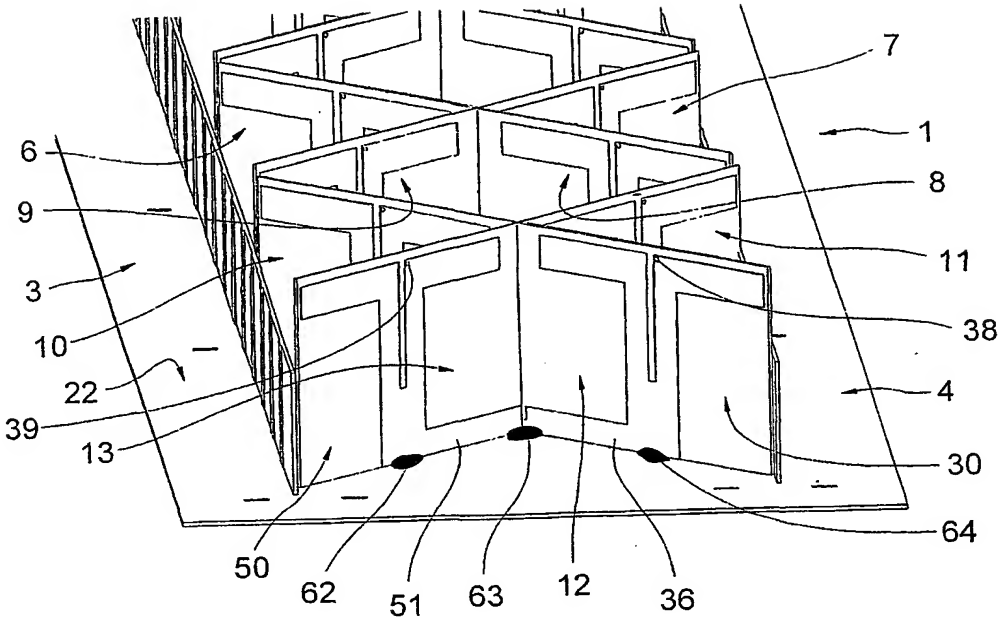


Fig. 3

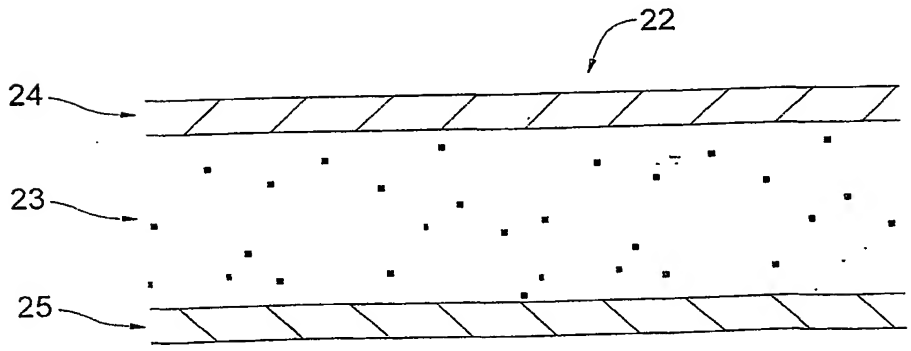


Fig. 3a

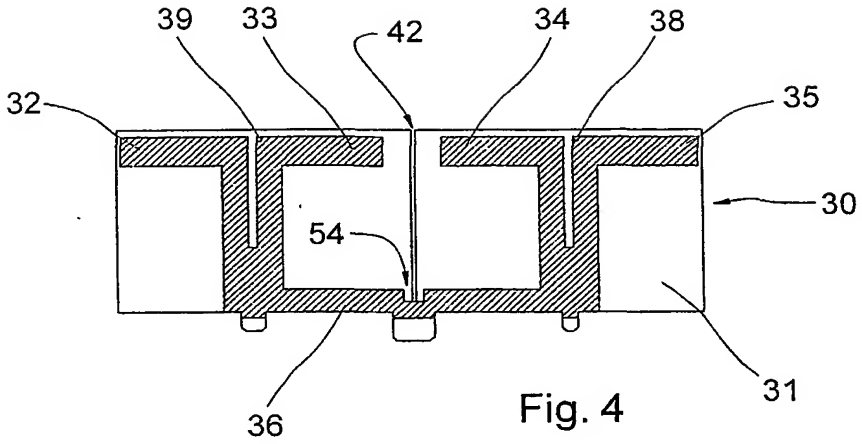


Fig. 4

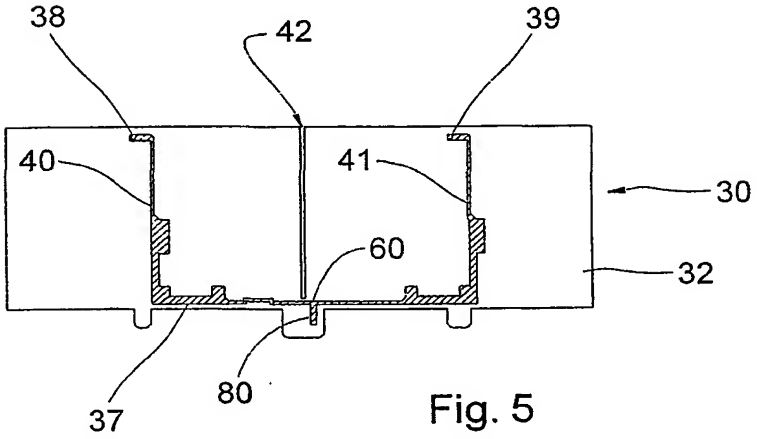


Fig. 5

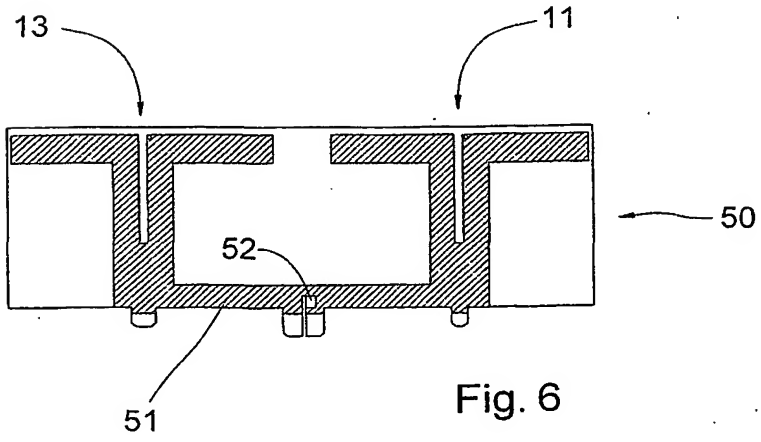


Fig. 6

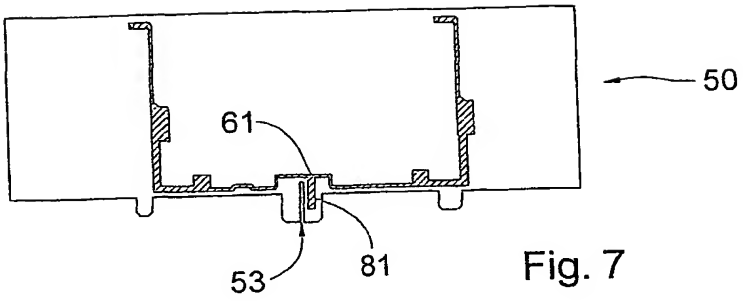


Fig. 7

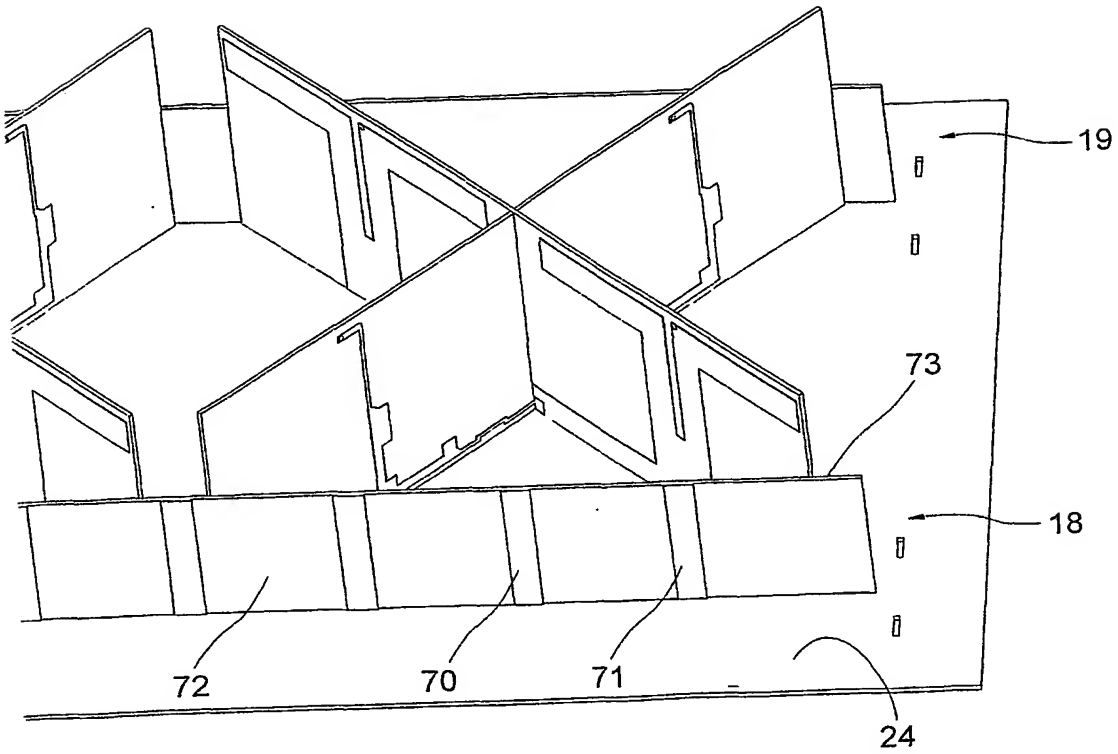


Fig. 8

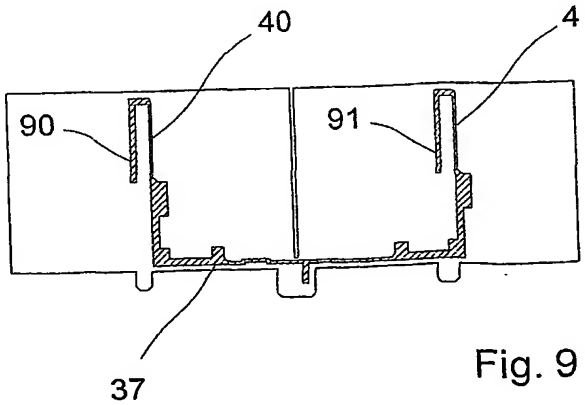


Fig. 9

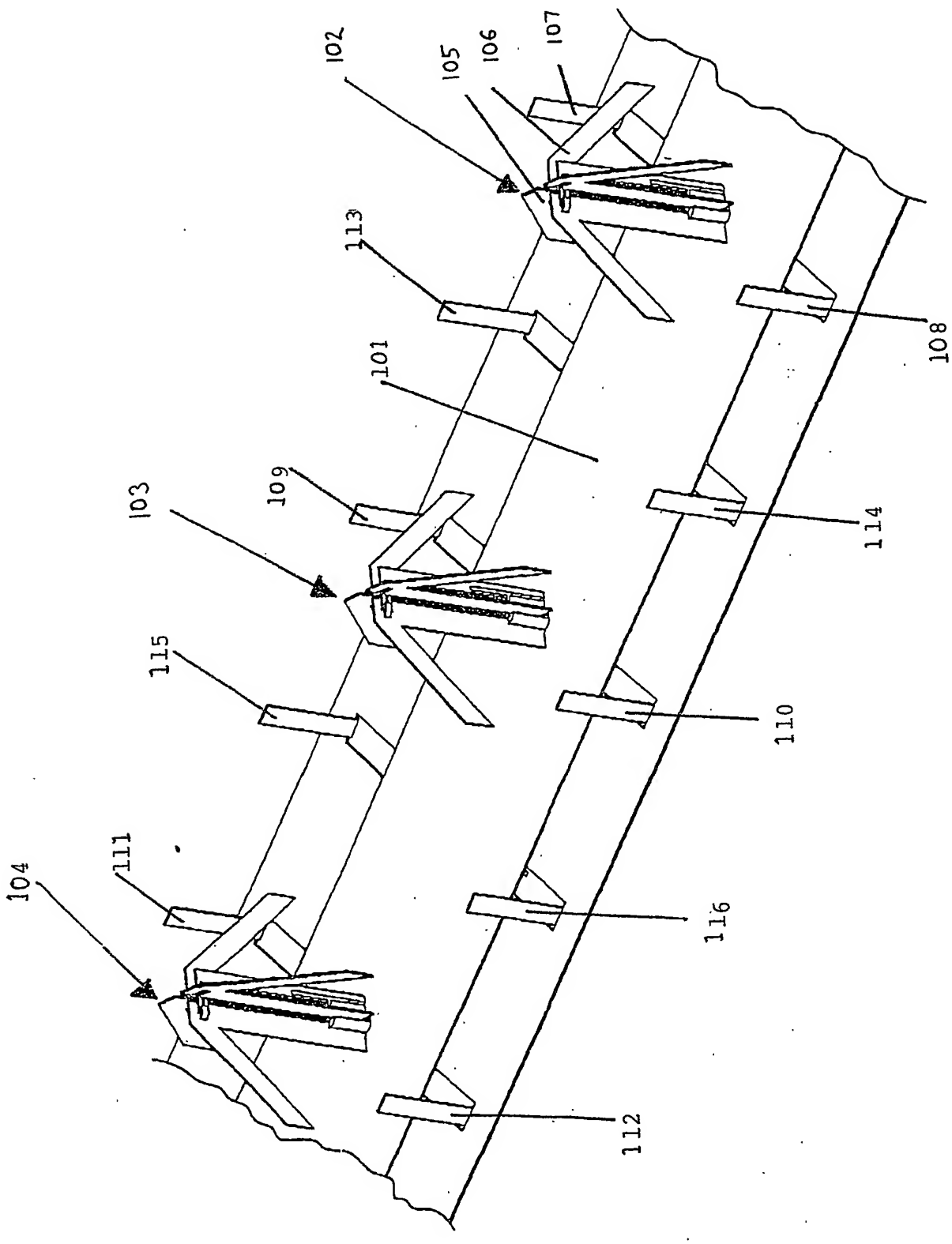
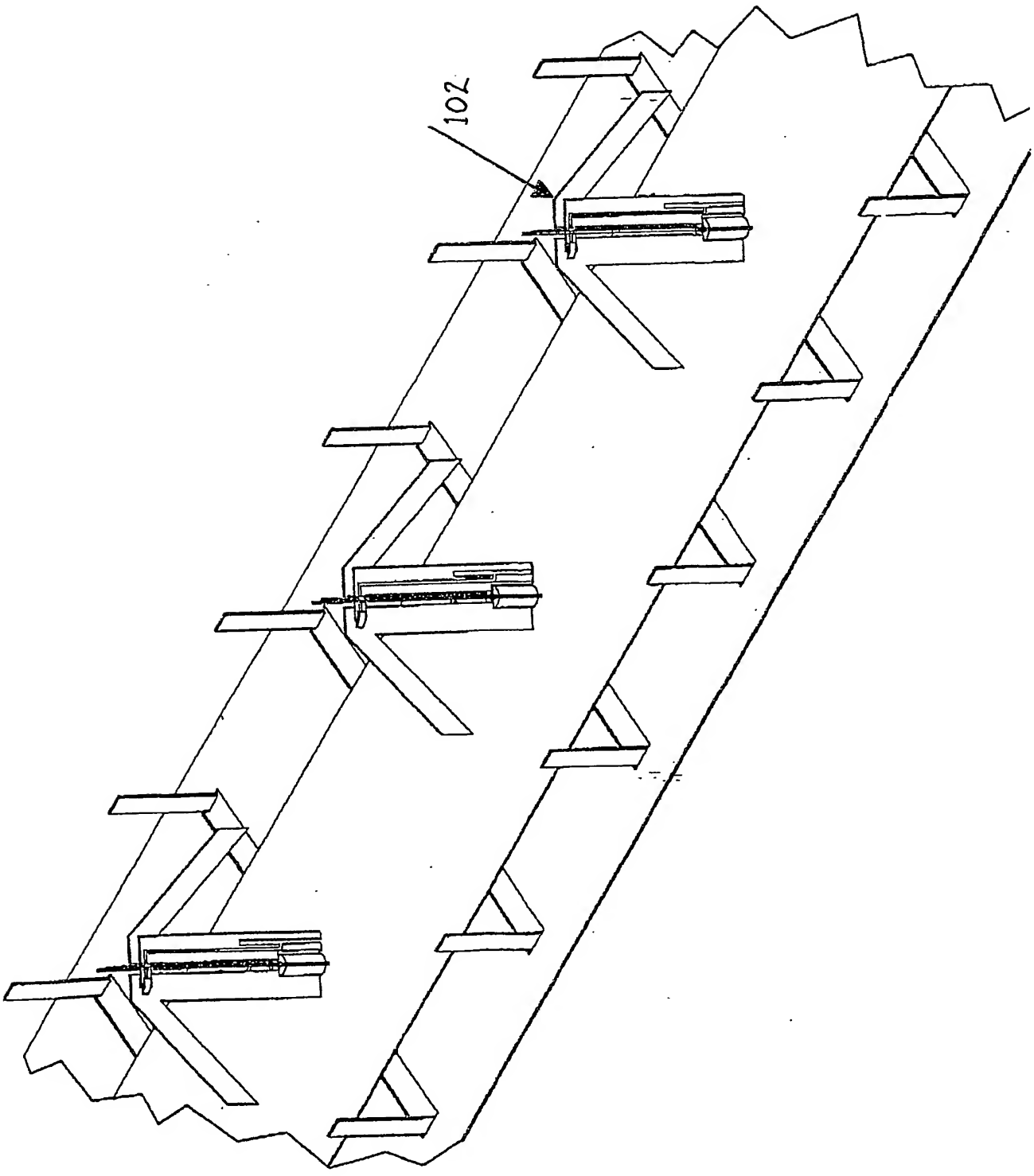


FIGURE 10

FIGURE 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ01/00191

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: H01Q 3/00 15/00 15/23

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT: antenna, dual polarisation, reflector, director, finger, plane, planar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 01/31738 A1 (TELEFONAKTIEBOLAGET LM ERICSSON) 3 May 2001 whole document	1-19
A	US 6195063 B1 (GABRIEL ET AL) 27 February 2001 abstract, Figs 1, 2, column 3, line 6 - column 4, line 34, column 4, line 58 - column 5, line 51	1-19

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

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Date of the actual completion of the international search	Date of mailing of the international search report
24 October 2001	26 OCT 2001
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **R.W.J. FINZI** Telephone No : (02) 6283 2213

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ01/00191

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 6034649 A (WILSON ET AL) 7 March 2000 whole document	1-19
A	WO 99/62139 A1 (KATHREIN WERKE KG) 2 December 1999 whole document	1-19
A	US 5966102 A (RUNYON) 12 October 1999 Figs 2-4, 6a-c, 7a-d, 8, 9a-d, column 14, line 28 - column 16, line 35 column 2, line 66 - column 3, line 65	1-19
A	US 5952983 A (DEARNLEY ET AL) 14 September 1999 Figs 5, 6, column 2, lines 7-41 column 3, line 3-30	1-19
A	US 5039994 A (WASH ET AL) 13 August 1991 Fig 1, column 1, lines 25-49	1-19

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/NZ01/00191

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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